DOCUMENT RESUME

ED 242 463 RC 014 684

AUTHOR Green, Rayna; And Others
TITLE Report and Recommendations: Conference on Mathematics in American Indian Education (Albuquerque, New Mexico, July 7-8, 1977).
INSTITUTION American Association for the Advancement of Science, Washington, D.C.
SPONS AGENCY Educational Foundation of America, Westport, Conn.
PUB DATE Feb 78
NOTE 35p.
PUB TYPE Collected Works - Conference Proceedings (021)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Administrator Attitudes; Adult Education; American Indian Culture; *American Indian Education; Computer Assisted Instruction; Continuing Education; Counselor Attitudes; Cultural Education; *Educational Strategies; Elementary Secondary Education; Human Resources; *Mathematics Achievement; Mathematics Anxiety; *Mathematics Education; Mathematics Materials; Mathematics Skills; Postsecondary Education; Questionnaires; Student Behavior; *Teacher Attitudes; Teacher Education; Testing
IDENTIFIERS Culture Based Education

ABSTRACT

Participants from all levels of Indian and mathematics education, the American Association for the Advancement of Science, and mathematics-related fields met to identify needs for mathematics education among American Indian students of all ages. In general, conferees were more pessimistic about the mathematics competence of American Indian post-secondary students than about the mathematics abilities of elementary students. They noted that the low achievement of American Indians in mathematics and mathematics-related fields was due to lack of training and that negative attitudes of teachers, counselors, and administrators were the most significant barriers to good mathematics education for American Indians. Conferees also noted that most testing determined deficiencies instead of proficiencies. Conferees stressed the need for more and better mathematics education for American Indian students at all levels. Participants noted specific problems and described specific strategies for mathematics education at primary, secondary, and post-secondary levels. They offered recommendations regarding networks of mathematics educators, advocacy efforts, assessment, information dissemination, materials development, and teacher training. Appendices include the conference agenda, a list of participants, a bibliography, and an article by Rayna Green entitled "Math Avoidance: A Barrier to American Indian Science Education and Science Careers." (SB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED242463

APR 1984
RECEIVED
ERIC/CRESS

REPORT AND RECOMMENDATIONS: CONFERENCE ON MATHEMATICS IN AMERICAN INDIAN EDUCATION

RAYNA GREEN, DIRECTOR
PROJECT ON NATIVE AMERICANS IN SCIENCE

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY
Rayna Green
TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)
✓ This document has been reproduced as received from the person or organization originating it.
☐ Minor changes have been made to improve reproduction quality.
• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

WITH

Janet Welsh Brown, Head
Office of Opportunities in Science

and

Roger Long, Project Assistant
Office of Opportunities in Science

sponsored by
the Educational Foundation of America
and
American Association for the Advancement of Science

February, 1978

SE 031 684

BEST COPY AVAILABLE

AASNEWSAAASNEWSAAASNEWSAAASNEWSAAASNEWSAAASNE
EWSAAASNEWSAAASNEWSAAASNEWSAAASNEWSAAASNEWSA
AASNEWSAAASNEWSAAASNEWSAAASNEWSAAASNEWSAAASNE

AAAS Project on Native Americans in Science

The needs of Native Americans for science education and scientific and technical manpower are being explored by the AAAS Office of Opportunities in Science Project on Native Americans in Science in a program initiated by the Office in January 1976. With support from the Educational Foundation of America and the Association, the Project undertook a 10-month effort which involved meetings of Native American scientists and educators; contact with Indian science and educational organizations; planning for educational institution needs assessment in science and mathematics; collecting and disseminating information on Native American science education and manpower development; and 6 weeks of field research, exploring the barriers to careers in science for Indian students.

The findings of this research are summarized in a published report, *The Barriers Obstructing the Entry of Native Americans into the Natural Sciences*. A comprehensive set of recommendations based on research and other activities of the Project has also been prepared and is being distributed to those best equipped to effect policy, implement programs, and remove the barriers. The "Barriers" study elucidates a number of significant areas for the improvement of science and mathematics education for Indians and the recommendations suggest strategies for effecting such improvement.

The study, which involved extensive interviews with American Indian college students, teachers, counselors, and program directors, indicates that poor precollegiate preparation in math and anxiety about abilities to succeed in math constituted a principal factor in choosing a career or college major as well as in general success in school.

The study suggests that

1) the Indian students rarely consulted high school counselors;
2) students had little remedial or advanced work available to them and developed programs of study on their own;
3) students rarely had Indian counselors or teachers; and
4) counselors rarely offered counseling services outside of disciplinary action.

The students who were science majors, particularly those in the allied health fields, had more role models, both Indian and non-Indian, than those not in scientific fields. Both their role models and their inspiration to enter a scientific field usually came with a work-related experience or activity. (For example, the men may have served in the Armed Services Medical Corps; the women in hospitals.) The study further indicates that most of the students, science and nonscience majors, preferred fields of study that were clearly work-related with cooperative or intern programs. They chose applied rather than theoretical or abstract disciplines and study problems, especially those that were of direct or indirect benefit to Indian people. Not surprisingly, it seems that those in special programs for Indians (e.g., biomedical sciences or engineering programs) with Indian counselors and staff support are more likely to graduate than students not in special programs. The research further suggests that serious conflicts between traditional Indian values and cultural factors such as sex role expectations and behavior tended to mitigate against choices of careers in the "hard" sciences.

While the barriers to Native American scientific education and manpower development are serious and extensive, a number of efforts to address the problems exist and are working. The AAAS Project on Native Americans in Science constitutes a major effort by a national organization to change the pattern of Indian underrepresentation in the sciences, and that Project is continually increasing its capacity to serve as a clearinghouse for information on Indians in science and science education. Other programs, based in national, state, and tribal institutions and agencies, also operate to address needs and an article in a future AAAS News section will discuss some of these projects.

RAYNA GREEN
SHIRLEY MAHALEY MALCOM
Project on Native Americans in Science

BEST COPY AVAILABLE

5 NOVEMBER 1976

reprinted from Science. V.184, pp. 597-98.

TABLE OF CONTENTS

I. Conference Report

II. Appendices

A. Agenda for the Conference on Mathematics in American Indian Education

B. List of Conference Participants

C. Bibliography of Materials and Projects on American Indian Mathematics Education

D. "Math Avoidance: A Barrier to American Indian Science Education and Science Careers," by Rayna Green

E. Indian Math Project Materials Resource Inventory

F. Indian Math Human Resource Inventory

Problems and Strategies in American Indian Mathematics Education:
Report of a Conference

Earlier investigations into the barriers obstructing the entry of American Indians into careers in the natural sciences (see background paper, Appendix A) directed our attention to the need to improve Indian mathematics education. While mathematics had always been included in our general efforts to improve health, scientific and technical science education, it became clear to the staff of the American Association for the Advancement of Science's Project on Native Americans in Science that math and competence in mathematics deserved special attention. With few exceptions throughout the various levels of Indian education, students, counselors, teachers and administrators report math as the stumbling block to general and professional scientific and technical education. In spite of the growing number of Indian students entering professional fields requiring various degrees of mathematics competence and in spite of those Indian students who have graduated from institutions requiring success in mathematics coursework, eventual success did not mitigate against the problems the students encountered in the process.

We were also aware however, in addition to the problems posed to Indian education by mathematics, of a number of successful efforts to address the problem in Indian educational settings. We wanted to find out more about those efforts and discover ways to make the most of what some teachers, students and curriculum developers know about learning mathematical competence. Our feeling was that Indian mathematics education, like Indian science, health and technical education has many rarely publicized successes, and we wanted this report to initiate an information system for math educators. Thus we decided to convene a conference to identify needs requiring the attentions of educators, educational institutions, funding agencies, and offices which serve as facilitators for improved Indian science education and manpower development. In addition, we felt the meeting would suggest some of the strategies that successful educators in Indian educational settings have employed and that could be more widely disseminated.

The Conference

The Conference on Mathematics in Indian Education, jointly sponsored by the Educational Foundation of America and the American Association for the Advancement of Science, was held in Albuquerque, New Mexico on July 7 and 8, 1977. Attending were thirty-six participants from all levels of Indian and general mathematics education as well as AAAS staff and guests from math-related fields in industry (see participant list Appendix C). All those invited had considerable experience, both as

individuals and as part of groups, in addressing difficult problems in mathematics education. As a group they brought impressive expertise to bear on the general topic of the conference. Essentially, the conference was centered around their special areas of expertise; sessions involved presentations by participants with ensuing discussion from others present. Topics (Appendix B) ranged from an identification of major problem areas (e.g., math avoidance, inadequate counseling, poor preparation, inadequate teaching, etc.) to discussions of strategies for addressing problems (e.g., computer-asssisted instruction, individualized instruction, tutoring, counseling, etc.).

The following report serves both as a conference report and as a discussion paper for future strategies in Indian mathematics education. This paper is not intended to be a comprehensive report on the state of Indian mathematics education nor are the recommendations meant to suggest comprehensive remedies for the problems outlined. This report simply suggests types of strategies that could be more widely employed, at the levels of both policy and implementation. Likewise, the recommendations are not always specifically targeted at agencies or categories of individuals. They are meant to suggest potential types of actions, agencies and actors who could be instrumental in changing Indian mathematics education for the good.

General Discussion

Those attending the conference had various concepts of how bad or good Indian math education is and various notions of how to address these problems and maximize the good. Most of those teaching at the post-secondary level had a more negative impression of the basic mathematics competence of entering Indian students than those at the elementary level had of basic mathematics abilities of their students. Both those at the pre-collegiate and post-secondary levels could point to successful efforts at interventions and to students who had gained the competencies they sought and needed. Certainly, the growing number of Indians graduating with degrees in health fields and engineering suggests both ability and successful attempts at attaining needed skills and understanding mathematics. Conferees felt, in general that the low achievements of most Indian students in mathematics and math-related fields is due largely to the lack of good training rather than to any factor mitigating against math competence inherent in tribal cultures. Though they recognize clear conflicts between modes of learning in Indian cultures, learning in contemporary math education theory and the expectations most math educators have for the learning of mathematics, they felt that good math education has not been available to most Indian students.

Conferees felt the factor most important in keeping Indian students from obtaining a good mathematics education is the prevalent feeling

among teachers, counselors and administrators that a more-than-rudimentary mathematics competence is beyond and/or irrelevant to Indian needs. Such assumption, conferees felt, is not only racist but educationally erroneous when one considers the growing number of Indians entering math-related and math-dependent fields such as engineering and medicine and when one considers the increase in science and technology-based economic development on reservations.

There was a special concern for the amount of testing performed on Indian students, especially those in federal schools or schools which, like Bacone, were historically "Indian" institutions. Most of those assembled felt that testing would be more profitable if less were performed on the students and more on the faculty and the curriculum. This sense was strongly connected to the conferees' sense that Indian students are largely tested for their deficiencies than for their proficiencies, and for their "deviance" in white cultural terms than for their "normalities" in Indian terms. Several conferees who work at the post-secondary level felt that Indian students are tested as "Indian," regardless of their background and distance from traditional cultural roles and lives. Often, they felt the Indian college students' need for remediation is more directly related to inadequate urban, public school preparation, for example, than to "Indianness" or federal school education. Testing, they felt, was aimed at revealing the traditional Indian student's inadequacies rather than inadequacies that would apply to Indian and non-Indian alike. Still, most conferees thought that more systematic and less "left-to-chance" stragegies might be developed for Indian students living in similar situations, or undertaking similar courses of study. At the same time, conferees expressed concern about making too much of "Indianness" as a category for consideration in the development of a mathmatics education format for students who happen to be Indian. Individual Indian students, they said, might and do respond to mathematics just like individual non-Indian students and they might, in fact, be treated similarly without special efforts to address "Indianness" as a component in developing problem intervention strategies.

In general, conferees agreed that the needs for more and better mathematics education for Indian students are extensive. They concurred that Indian people need better math education at all levels: for general education for daily living, for careers in math-related fields, for special tasks, and for general knowledge that would answer Indian needs. There was also agreement that more Indian math teachers and specialists in math-related fields are essential for the improvement of Indian math education and Indian daily living and economics, but that the special training of all mathematics teachers working in Indian settings is desirable for the maximum benefit to Indian people. Agreed as well was that more materials developed especially for use in Indian education ought to improve matters, and that more and improved counseling

of Indian students with regard to the needs for mathematics competence is vitally essential. All concurred that a basic mathematics education, as it is customarily taught may be inappropriate for the needs of most people, and most certainly for Indians on reservations. Most conferees insisted that all students, including Indian students, would benefit from a pruning of standard math curricular offerings to contain those basic skills and concepts relevant to their daily life, and to business and professional competencies. Yet, conferees stressed the need for more, and not less mathematics education for most people and the need for concerted attempts to instruct people in those competencies which would enable them to "think mathematically," that is, to be able to draw on mathematics for creative and pragmatic solutions to many problems.

The strategies conferees presented can be understood as frameworks for the recommendations suggested here and as frameworks for a discussion on Indian education in general. The more specific topics and areas of discussion addressed at the Conference are:

Problems at the Secondary Level

Those conferees who currently work or who have worked in junior and senior high schools agreed that the major problems in Indian mathematics education at those levels are two-fold: students' disaffection from mathematics that had already developed by the time of post-elementary school entrance and their increasing lack of preparation as demands for mathematical competence increased. Here conferees focused largely on students rather than on teachers, though conferees agreed that many math teachers and counselors perpetuated the mystique of math as hard and inaccessible to all but the brightest students. But they asserted that this age-group's inclination toward active rebellion from stringent discipline--especially as it is practiced in federal and parochial schools, presented problems that even good teachers cannot entirely resolve. Indian teenagers, more vocal like their non-Indian peers, and far from silent like their younger siblings, often reject the most disciplined, visibly Western, and career-directed forms of education -- including math, and the sciences -- and begin to embrace those areas of study -- he social sciences and humanities -- which seem to have more relevance in their own individual and tribal best interests. Teachers in high schools, more specialized than those in the elementary grades, are generally trained to teach in their subject areas, but may still lack the specialized training and commitment it would take to reclaim the disaffected, teach them what they need to know, and counsel them effectively in their own best interests.

Beyond the concern for students and teachers at the junior high and high school levels, however, conferees felt that too little attention

has been paid to math materials development for secondary education. Furthermore, they agreed that too little attention has been paid to strategies which would retain and encourage students' interest in math, especially for those students -- i.e., minorities and women who are rarely encouraged into math-related fields. Encouragement for mathematics study at this level is, they felt, too often tied to fulfillment of requirements for college entrance or vocational program exit. Both goals mitigate against genuine mathematical competence for daily life and against students' interest in math except for those already tracked into math-related vocations. Indian students, like other minority students, are the least likely to be tracked into such fields and the least likely to have been encouraged beyond elementary math.

Problems at the Elementary Level

Most of the concerns addressed by conferees working in elementary programs were aimed at teachers and teacher preparation rather than at students. Those teachers working at the elementary level had an especially acute concern for the lack of training in and lack of enthusiasm for mathematics teaching they saw in a majority of teachers at that level. They felt that their highly diversified and heavy teaching loads, combined with an inadequate training for and probable dislike of mathematics, would perpetuate the cycle of mathematics avoidance.

Teachers from institutions in highly traditional communities did raise issues related to "Indianness" or cultural learning styles. Most remarked upon was the phenomenon of Indian childrens' silence in the classroom. Conferees knew of the body of literature on the subject and also had perceptions based on experience. They emphasized the significance of silence in the context of contemporary mathematics education which is largely "discovery" based. The experience of those in the K-8 grades told them that traditionally-raised Indian children are interested in mathematics and capable of doing what is asked of them in those grades; yet, they are not participatory in the ways that contemporary teaching and learning strategies demand they be. All agreed that the assumption that traditionally raised children would be more comfortable with other forms of the teaching-learning experience than the discovery method is a better assumption to make than that Indian children are stupid, hostile, uncomfortable, afraid to speak or afraid of learning. Most of the elementary teacher's strategies for addressing children's silence read like those of teachers at post-elementary and collegiate levels. That is, they had tried individualized, one-to-one tutorial and teaching sessions to provide a supportive and indeed, more traditional framework for learning. Though they wanted to move away from a conventional curriculum, most agreed that they as teachers needed to learn a more conventional or traditional knowledge "giving" rather than "discovering" method of teaching in working with constructive possibilities for Indian childrens' silence in the classroom.

Strategies for the Primary and Secondary Levels

Computer-assisted instruction for pre-collegiate education has drawn the attention of educators throughout the country and Indian educators are aware of its uses; committees and administrators remain suspicious of yet another "innovation," especially one so expensive. Nevertheless, some initial and long-range experiments at CAI (Computer-Assisted Instruction) at the pre-collegiate level have been persuasive. One such long-running use of CAI has been at the All Indian Pueblo Council's program, in operation for five years and now at several pueblos, federal schools and some public schools with a high percentage of Indian students. The Council staff feels, quite strongly that what ought to be taught in math varies from institution to institution and individual to individual. Thus, they ask teachers, parents, students and administrators what they need before they develop or implement programs. Second, they feel that the machinery is limited and that only certain things can be taught by CAI. Thus, they use the machine to teach approximation and perception, for example, but not for teaching metric volume. The staff feels that CAI is supplementary only and that one cannot replace teachers or tutorial work with the computer. However, the Council CAI staff believes that the Pueblo students who use the machine like the privacy and individual pace of the machines, and this fact is particularly appropriate for Indian children highly sensitive to the pressures of public achievement and failure and conditioned as well to a silent involvement in learning. Computer-Assisted Instruction, as used by the Council staff, has been used primarily for elementary and secondary training, but they believe it can have capabilities for use with adults in GED (General Equivalency Degree) and vocational training as well as for aquisition of general math proficiency. This latter utility, promises an extended functional capability for health planning and delivery through satellite dissemination, and a cost-efficient investment for rural, remote tribes with limited and unspecialized human and material resources in education and health.

Another approach seriously discussed at the conference included culturally based education, especially appropriate for pre-collegiate math and science. The Native American Materials Development Center, for example, is working with Navajo bilingual and biliterate teacher aids and community members and students to produce pre-collegiate instructional materials for math and science. The project places stress on retaining people in the community -- training teacher aides, for example -- and on student involvement in material and curriculum development. They attempt, for example, to discover how the culture uses mathematical concepts (e.g., in astronomy, cookery, weaving or silversmithing) and work to make the terms usable in Navajo and English.

A problem which arises in culturally-based education defines a specific need for bilingual dictionaries of scientific and technical

terms for use in tribal education. The Navajo Linguistic Society has drawn up a proposal for such a dictionary, but each tribe and teacher working with the tribes needs to consider the possibilities at least of rudimentary word lists. Moreover, finding math teachers who are both fluent and literate in Indian languages and English is a major problem. Nevertheless the conferees felt that the attempt must be made if effective education is to take place in language retaining Indian cultures. Navajo educators feel there is some evidence that bilingual and biliterate children score higher on standarized tests and demonstrate higher degrees of achievement than monolingual, mono-literate children. Thus the effort to teach and learn mathematics from both linguistic perspectives seems worth the considerable effort that will be required.

The development of culturally-based mathematics materials is a goal in Papago educational services as well, though not yet a reality in terms of developed and usable instructional materials and teacher training efforts. Teachers and teachers aids there have already translated the multiplication tables into Papago and these are being used in the schools, but more extensive and culturally-profound efforts -- the use of Papago mathematical skills and concepts, as seen, for example, in the gambling games -- is a future goal.

Teachers at the Pierre Indian Learning Center also plan to work with three Indian teachers involved in cultural programming to develop math materials based on Lakota (Sioux) arts. Other culturally-based curriculum materials for mathematics teaching at the secondary level have been developed by a teacher in the Montana and California Indian schools who involved the older community members and the students in producing examples for math learning from Plains Indian cultures. From dances, hand games, gambling games, astronomical information, designs and sign language, he has produced an as yet unpublished textbook used by multitribal students at the secondary level. One of the advantages in using culturally based math education strageties is that the teacher, Indian or non-Indian, can become the learner and the students can succeed at both knowing and teaching. Though this role reversal or role change for both student and teacher would seem to violate the traditional teacher-as-elder-and-knower role, in that the teacher seeks to become a "knower" of knowledge not automatically conferred even in tribal cultures, thus legitimizing his/her "ignorance."

Problems at the Post-Secondary Level

Even though specialized training for mathmatics teachers is not a major need for teachers at the secondary and collegiate levels, the continuity of training and the specificity of training for teaching in Indian settings does remain a problem. At the small tribal colleges, the scarcity of staff and funds for staff in the sciences and mathematics make released time or sabbatical for further training virtually impossible.

Inadequate student preparation in mathematics, both for competencies needed to pass required A.A. or B.A. coursework or those needed for further math-related training in the sciences however, was the single factor pointed to in problems at the post-secondary level. Lack of adequate preparation and competence further affected Indian students trying to attain the skills required for advanced training in their chosen fields. Add to lack of student preparation a general lack of special attention to mathematics for specific professions, and the cycle is again perpetuated.

Strategies in Post-Secondary Education

At schools such as Bacone College, a National Science Foundation Minority Institutions Science Improvement Program (NSF/MISIP) grant supported an individualized, programmed learning system that helps students through the remedial steps toward the A.A. degree and has the further capability of pre-professional mathematics instruction should a student require such training. While remedial training in mathematics is often necessary, Indian students face a liability in undertaking remedial courses not common to their non-Indian peers. Bureau of Indian Affairs (BIA) scholarships are provided only for full-time, non-remedial coursework, thus the student's financial support is often imperiled by needed, but risk-filled remedial coursework. At Bacone, the "IP" (In Progress) grade used in the individually-programmed mathematics courses enables the student to retain scholarship money while obtainig necessary basic mathematics education.

Bacone, Haskell, and virtually all the tribal colleges like Oglala Sioux, as well as professional programs in majority insitutions like the Indian engineering program at the University of New Mexico, had used some form of individualized instruction and tutorial aid for Indian students. Most schools had used a combination of specially-developed or commercially-developed or commercially available programmed individualized instruction along with tutorial aid from both peers and non-peers. At the University of New Mexico, administrators found a direct correlation between successful tutoring and student motivation, though they found little correlation between tutoring and grades. All conferees remarked on the Indian student's generally positive response to personal instruction, and all felt that Indian peer tutors held the promise of good role models where few or no Indian math teachers existed. Peer tutors can exacerbate students' doubts about their own competencies in contrast with their tutors' while Indian or non-Indian "teachers" can offer a supportive but non-threatening traditional authority model to the student. Conferees expressed concern for the tutors as well as tutees, having perceived that some Indian tutors were thoroughly

bored or disenchanted with the teaching process as they found it in tutoring. Others were delighted at the prospect of communicating ways to learn material they had learned, and proved good in the short term forms of tutorials. But all agreed that the success of tutors, peer or otherwise, and in an Indian context or not, depends both on the personalities and competence of the tutor and the readiness of the tutee. Most educators concurred that task or job-specific mathematical eduCation (e.g., mathematics for engineering) is more appropriate for science-base pre- or professional-track students; yet, very few Indian students with mathematics deficiencies are prepared initially for a purely task/job based math input and few schools and teachers are prepared to offer such instruction even when the students are ready for it. The Native American Engineering Program at the University of New Mexico is an exception and has scheduled such a curriculum effort for the engineering students there. Other conference participants have had experience in teaching particular sets of skills for professionally tracked students (i.e., metric quantification for dosages for nursing students) but few instructors have had the opportunity to structure entire math courses for students with such specific professional needs.

Problems and Strategies in Adult and Continuing Education

Adult education in mathematics instruction is needed both on remote reservations and in urban areas, either for GED and for specific vocational skills and for daily living such as leasing calculations, cost-effective shopping and home management. Those conferees who teach at Indian post-secondary institutions also specified needs for remedial tools for older students who plan to further their education as well as for those who need short-term, specific skill work in mathematical competencies. Often, teachers have found that standardized texts for teaching basic skills were either too advanced for their students or too "elementary" in tone for adults.

Most teachers like those at Oglala Sioux Community College, have therefore created materials for specific use with Indian adults in the specific settings in which adult education takes place in Indian country. Such materials always speak directly to the specific needs and characteristics of the Indian adults using the materials. However, those who had developed their own materials with little time and support to do it, expressed a need for special attention to be paid at the national level for the need for such curricula and for the exchange of materials already developed. All conferees expressed a need for materials developed for specific situations and categories of students, such as the adult student returning for specific skill acquisition, but they are convinced as well that some major needs in Indian education can be defined which would produce materials of wide use potential.

Most teachers who had worked or who presently work in Indican education agreed that mathematical learning systems which use games and gaming techniques work well with Indians whether they are children, adults, students in a "normal" progression of courses or "special" students. Several had prepared materials especially for their own students and had obtained comercially available materials which had games at the basis of learning. They felt, though little research evidence for the assertion exists, that the success of games in Indian math education was related to the prevalence of game playing and gaming in Indian tradition, and several teachers had initiated research into traditional games in order to develop materials appropriate to their students' cultures and mathematics competency needs.

Recommendations

The recommendations offered here are a composite of suggestions made by participants in the Conference on Mathematics in Indian Education and those derived from the experience of the staff of the Project on Native Americans in Science. They are primarily Project recommendations made on the basis of what staff heard and learned at the Conference and at many meetings with educators across the country. We have tried to give formal shape and focus to what conferees and other educators in Indian settings have told us, though the ideas, documentary examples and feelings about what's wrong, right and possible in Indian mathematics education are theirs.

1. Network

The conferees saw themselves as the potential nucleus of a network of mathematics educators working in Indian settings and sharing a common interest in improving the math education of Indian people. A well-developed network could provide advocacy and clearinghouse functions and stimulate improved support and training for math. A coalition of educators sensitive to needs and willing to undertake local and national initiatives could organize meetings with policymakers, present papers at meetings such as that of the National Indian Education Association and the National Council of Teachers of Mathematics, develop and guide the clearinghouse, materials development and assessment activities aimed at increasing awareness and changing the system of delivery for Indian mathematics education. The overall network goals would be to:

-----increase the priority for sound and useful mathematics education for all Indian people;

-----increase the numbers of Indian people trained in mathematics or math-related fields;

-----increase the general mathematics competency of Indian children and adults for career entrance and for use in daily life and work; and,

-----provide an effective in-service training and support network for math teachers and curriculum developers in Indian educational settings.

2. Advocacy

Advocacy efforts are generally needed, conferees felt, to educate federal, state and local pocicymakers, educators and funding agencies about the needs for an improved Indian methematics education. Those efforts would be directed also toward parents, tribal councils, and tribal education agencies, who are gaining increasing control over Indian education and who need the kinds of assessments that advocates can provide. Finally, advocacy efforts are needed to develop sources of support, financial and otherwise, for efforts which have had little previous support in Indian education. Thus, the identification, targeting and lobbying of the individuals, agencies and interest groups that could potentially impact on math education is a necessary first stepo in Indian math education's improvement. The Indian mathematics network and the AAAS Project on Native Americans in Science could begin with the Indian and science organizations and the tribal and state and national agencies most responsible for Indian educational delivery.

3. Assessment

An assessment of the mathematics education available to Indian students should include an identification and study of who the math teachers of Indian students are, what kinds of problems they face, what their training and experience is, what kinds of solutions they have provided for problems, and what they feel they need to do the job they want to do in teaching mathematics.

4. Clearinghouse

A second but parallel tier of efforts at improving Indian mathematics education are centered around information gathering and dissemination, and, in fact, form the support framework for advocacy efforts. Conferees felt that the provision of information supportive of change in educational priorities to educational policymakers and providers alike, and the exchange of information and materials among providers themselves would offer the basis for continuing and fruitful change.

The clearinghouse would enable teachers, curriculum developers and other interested parties to obtain materials, identify potential resource persons and exchange ideas for pedagogical strategies and materils development in an effective low-cost manner. The identification of human resources -- especially those Indian people in mathematics, math-related fields and mathematics education who could be used as visitors to schools where no Indians teach mathematics and where reinforcement of the image of Indians as mathematically competent -- needs special support. As well, the clearinghouse would develop a human resource bank of non-Indian persons whose special skills and commitments make them viable actors in the improvement of Indian mathematics education. For example, the clearinghouse would be able to identify educators for advisory support who have initiated or directed Indian or other minority science projects in majority institutions. One of the tribal colleges would be an appropriate location for such a clearinghouse if adequate support were obtained.

5. Materials Development

While conferees recognized the utility of commercially developed materials for Indian education, many felt that materials produced especially for the various constituencies of Indian education and directed toward their age, tribal characteristics and needed skills were necessary for maximum benefit. Many of those assembled for the meeting had already developed such materials or reshaped commercial materials for use in Indian settings and sensed that what was lacking was the dissemination a clearinghouse could provide as well as future incentives for educators to develop appropriate materials.

6. Assessment

In spite of the consistency with which some problems and solutions appear in discussions on Indian mathematics education, a careful scrutiny of the state of that art has not yet been undertaken. Such an examination ought to be made, perhaps by a combined effort of the Bureau of Indian Affiars, the Indian-Controlled School Boards, the Office of Indian Education in the Department of Health, Education and Welfare, and National Council of Teadhers of Mathematics and the National Science Foundation.

7. Training

Another essential kind of effort to build an improved Indian math education is the recruitment and training of teachers, counselors and

curriculum developers for specific roles in mathematics education. Conferees felt the need for a nationwide effort at training math teachers specifically for Indian settings and for an ongoing and national attempt to coordiate in-service training for teachers, teacher aides, counselors and curriculum developers. They felt, quite frankly, that little hope existed for impacting on state-controlled teacher training programs, yet they strongly urged that those agencies most concerned with Indian education develop directives for programs specifically aimed at teachers planning to work in Indian settings and that those programs have priorities for training in mathematics education. Moreover, they urged that those same agencies--the Bureau of Indian Affairs, the Indian Controlled School Boards, the Office of Indian Education in HEW--as well as potential funding sources such as the National Science Foundation assist the development of continuing in-service programs aimed at providers in Indian educational institutions and directed toward change in Indian mathematics education improvement.

Conclusions

Conferees felt that a more profound and rapid changed in Indian Mathematics education would result if the kinds of interchanges and educational opportunities specified in this report were undertaken together as part of a unified plan. Advocacy backed by information gathered, developed, and desseminated to a nationwide audience and translated into local action by careful in-service training would, conferees thought, make the most of the human and material resources available for the improvement of Indian mathematics educaiton. This report attempts to suggest that the time is right for concerted and strong action in Indian mathematics education. The tribal motivation for Indian manpower development in math-related fields -- health, the hard sciences, technical fields, management -- is certainly there. The new emphases in Indian country on energy development and on control and management of tribal resources make the motivations all the more acutely felt. The concern for Indian education has shifted away from the sole emphasis on Indian school pathology as the problem and Indian cultural studies as the solution, and many forms of change now seem possible. There is moreover a new consciousness in the federal and private agencies about the forms that Indian educational self-dertrmination can take with their support. The time for attention to the third "R" is now, and Indian educators appear eager to give that attention.

AGENDA

Conference on Mathematics in Indian Education

Albuquerque, New Mexico

July 7-8, 1977

Wednesday, July 6

6 pm	Get-Acquainted Session: Opening Remarks, Rayna Green, Director, Project on Native Americans in Science and Janet Welsh Brown, Head Office of Opportunities in Science, American Association for the Advancment of Science
7:30 pm	Dinner, La Placita, Old Town

Thursday, July 7

6-8 am	Breakfast
8:30-9:30 am	The Problem and the Need: Mathematics in American Indian Education, Work and Daily Life, Rayna Green
9;30-11:30 am	Strategies in Indian Mathematics Education: Approaches to Learning and Instruction Math for Women: Implications for Indian Education, Nancy Kreinberg Remedial Mathematics, Ann Sperling, Diane Joachim Kindergarten-Grade 6, Janet Valenzuela, Luke Thompson Grades 7-12, Ralph Hart, Malik Younus Post-Secondary, Pat Gore, Laurene Brady, Mark Wilson
11:30-12:30	Lunch
1-5 pm	Task-Specific Mathematics: Math For Specific Jobs and Constituencies Math For Engineering, Industry, Science and Health, Mike Bevacqua, John Kaskaske, Lora Shields Math For Teachers, Paula Platter, Ted Reed In-Service Teacher Training, Gene Maier
5-6 pm	Dinner
7-9 pm	Mathematics Program Development: Faculty, Curriculum, Funding, Tom Cummings, Maya Cramer, Dick Gibbs

Friday, July 8

6-8 am	Breakfast
8:30-11:30	Tools and Approaches in Indian Mathematics Education (cont'd after lunch) Computer-Assisted Instruction, Scott Bell Peer Tutorials, Peer Teaching, Individualized Instruction, Pat Gore, Mike Bevacqua Culturally-Based Mathematics Education/Bilingual Curriculum Development, Janet Valenzuela, Malik Younus
11:30-12:30	Lunch
1-4 pm	Culturally-Based and Bilingual Math Curriculum (continued) Mathematics for Daily Life Strategies for the Future

Conference on Mathematics in Indian Education

July 7-8, Albuquerque, NM

AAAS Staff

Janet Brown, Head
Office of Opportunities in Science
American Association for the Advancement of Science
Washington, DC 20036

Rayna Green, Director
Project on Native Americans in Science
Office of Opportunities in Science
American Association for the Advancement of Science
Washington, DC 20036

Conference Participants

Scott Bell, Director
Computer Assisted Instruction Project
All Indian Pueblo Council
PO Box 6507
1015 Indian School Rd., NW
Albuquerque, NM 87107

Michael Bevacqua
Mathematics Department
University of New Mexico
Albuquerque, NM 87131

Laurene Brady
Math/Science Department
Oglala Sioux Community College
Pine Ridge, SD 57770

Laura Cameron
Mathematics Department
University of New Mexico
Albuquerque, NM 87131

Cliff Capp
Intercultural Center
Fort Lewis College
Durango, CO 81301

Tom Cummings and Maya Cramer
Native American Materials Development Center
407 Rio Grande Blvd.
Albuquerque, NM 87104

Dick Dubois
Mathematics Department
University of New Mexico
Albuquerque, NM 87131

Richard Gibbs
Mathematics Department
Fort Lewis College
Durango, CO 81301

Ralph Hart
Stewart Indian School
Carson City, NV 89701

Dominick Jaramello
Native American Program
College of Engineering
University of New Mexico
Albuquerque, NM 87131

Diane Joachim
Pierre Indian School
Star Route 3
Pierre, SD 57501

Melinda Reagor
AIPC Contract Staff
Albuquerque Indian School
Albuquerque, NM 87107

John Kaskaske
NASA - Goddard Space Flight Center
Code 572.3
Greenbelt, MD 20771

Nancy Kreinberg
Lawrence Hall of Science
University of California
Berkeley, CA 94720

Chick Burnett
BIA-IERC
123 4th St, SW
Box 1788
Albuquerque, NM 87103

Eugene Maier, Director
Oregon Mathematics Education Council
325 13th St, NE Room 301
Salem, OR 97301

Mason McCracken
Native American Program
College of Engineering
University of New Mexico
Albuquerque, NM 87131

Paula Platter
Education Department
Southeastern Oklahoma State University
Durant, OK 74701

Ted Reed
Faculty Programs
National Science Foundation
Washington, DC 20550

Miguel Rios and Maria Rios
Sandia Laboratories
Kirtland AFB
Albuquerque, NM 87116

Jesus Martinez
Sandia Laboratories
Kirtland AFB
Albuquerque, NM 87116

Lora Shields
Biology Department
New Mexico Highlands University
Las Vegas, NM 87701

Jim Shorty, Director
Native American Program
College of Engineering
University of New Mexico
Albuquerque, NM 87131

Ann Sperling
Pierre Indian School
Star Route 3
Pierre, SD 57501

Paul Sward
BIA-IERC
123 4th St, SW
Box 1788
Albuquerque, NM 87103

Charles Sonntag
Laguna Elementary School
Laguna, NM 87026

Paul Cooka
Jemez Day School
Jemez, NM 87024

Luke Thompson
Indian Oasis School #40
Sells, AZ 85634

Paul Tweeton
Education Department
University of New Mexico
Albuquerque, NM 87131

Janet Valenzuela
Indian Oasis School #40
Sells, AZ 85634

Mark Wilson
Math Department
College of Ganado
Ganado, AZ 86505

Ernest Magnuson
BIA Education
Window Rock, AZ 86515

Malik Younus
Sherman Indian School
Riverside, CA 92501

Patrick Gore
Chairman, Math/Science
Bacone College
Muskogee, OK 74420

Jim Anderson
Elec. Engineering Program
University of New Mexico
Albuquerque, NM 87131

Bibliography of Materials and Projects on American Indian Mathematics Education

All Indian Pueblo Council's Computer-Assisted Instruction Project. Contact: Scott Bell, AIPC, Post Office Box 6507, 1015 Indian School Road, NW., Albuquerque, New Mexico 87107

Brady, Laurene, Math Curriculum, 1976. Oglala Sioux Community College, Pine Ridge, South Dakota 57770

Closs, Michael, "A Survey of Mathematical Development in the New World," Ms., 1976, Department of Mathematics, University of Ottawa, Ottawa, Canada

Gore, Pat and Eugene Speck, Basic Math 1013 P.S.I: Study Guide, Objectives and Suggested Procedures. Bacone College 1975

Green, Rayna, "Math Avoidance: A Barrier to General Education and to Career Access for American Indians," Ms.1977, AAAS Project on Native Americans in Science

Green, Rayna, "Final Report and Summary of Proceedings of Conference of Science and Math Faculty of Native American Colleges," AAAS, May, 1977, pp. 14-17

Math for Engineers, University of New Mexico Native American Engineering Program. Contact: Michael Bevacqua, NAPCOE, School of Engineering, University of New Mexico, Albuquerque, New Mexico 87131

Metrics for Tribal Adult Education at Choctaw, Contact: Dr. Paula Platter, Southeastern Oklahoma State University, Math Department, Durant, Oklahoma 74701

Navajo Culturally-Based Bilingual Mathematics Curriculum Development Project, Contact: Tom Cummings, Native American Materials Development Center, 407 Rio Grande Boulevard, NW., Albuquerque, New Mexico 87104

Navajo Math Curriculum Guidelines Project, Dick Gibbs, Math Department, Ft. Lewis College, Durango, Colorado 81301

Papago Tribal Education Project in Culturally-Based Math Education, Contact: Janet Valenzuela, Indian Oasis School, #40, Sells, Arizona 85634

Younus Malik, "Math Curriculum With Emphasis in Examples from Plains Indian Culture," Ms., Wyoming Indian High School, June 1975.

MATH AVOIDANCE: A BARRIER TO AMERICAN INDIAN SCIENCE EDUCATION AND SCIENCE CAREERS

Rayna Green

Of all minority groups in the United States, Native Americans are the most poorly represented in the natural sciences, the health sciences and mathematics; yet Native peoples are the most needful of any minority group of status improvement in the areas of health, education and social welfare. Indian health needs are generally well-known, as are the grim facts of Indian underachievement in education. Even though the necessity for more Indian professionals in all fields and for economic development throughout the Native world tie together the major areas of concern, other needs beyond basic health care delivery and education exist in plenty. Most land-based Native Americans are in a serious struggle for the retention and development of the land they own, and in that struggle lies a potential for economic development which can change health care and education patterns for the good. Thus, Native engineers, geologists, hydrologists, resource planners and managers, conservationists, foresters, agronomists, aquaculture specialists, chemists, geneticists, animal husbandry specialists, and botanists--are all needed for resource development, management, and planning on Indian lands. Additionally, Indian teachers and programs in these fields are needed to raise the general educational level of Native people, as well as to provide meaningful career options for all Indians--rural, urban, land-based and not.

A number of agencies--Indian and non-Indian controlled programs operating at the national, state, and local levels--have begun to work in changing the pattern of Indian underrepresentation in the sciences and technical fields. As Director of the AAAS Project on Native Americans in Science, I have prepared reports which attempt to offer perspective through analysis of the problem ("The Barriers Obstructing the Entry of Native Americans into the Natural Sciences," MS 1976) and through a plan for remedial action ("Recommendations for the Improvement of Science and Mathematics Education for Native Americans," BIA Education Research Bulletin, Vol. 5, #1, January 1977). This article addresses one of the barriers to a scientific education and career and discusses various strategies for removing this particular obstacle from the path of American Indian students. The full research report and the set of recommendations are available from the Project on Native Americans in Science at AAAS. The report, the recommendations and this article are based on a year of formal and informal interview and discussion with Indian students, educators, counselors, teachers, scientific, technical and health professionals, and program developers as well as with non-Indian science educators, advisors, funding agency professional association and staff.

In general, I have found that many different kinds of barriers to the entry of Indian students into the sciences exist: some are cultural and attitudinal, some institutional, others technical and skill-related. In general, Indian students in the study appear to have numerous barriers. Some barriers are obvious, while others are more subtly harmful: poor or no counseling, bad; unskilled teachers; a negative image of science and scientists; no role models; lack of money for college; fear of failure; poor preparation in basic skills; lack of community priority for collegiate

education, parental, family or marital problems, culture conflicts, and poor study habits; all contributed to retard educational progress. Those blocks to their general education are even bigger when it comes to choosing "deviant" careers in science and math. Of all the skill and attitudianlly-related obstacles to success in both their general education and to a potential choice of a career in the sciences and technical fields, however, mathematics anxiety and math avoidance seem to be the most pervasive and serious. Poor preparation in math, combined with a widespread and debilitating form of math anxiety--as Shiela Tobias has termed it in her reports of research on women at Wesleyan--apperar to be a singularly important factor in both collegiate success and career choice.

Almost all of the Indian students in the "Barriers" study--even those who had chosen the sciences and technical fields where exposure to, need for, and use of math is much greater than in the humanities--expressed a great anxiety at being able to do and understand math. Most expressed a distaste for math even when they were relatively competent in the skills required of them. And even if their anxieties about ability to do math had been allayed by recent successes, the power of their real or imagined failures in the past caused nothing but trouble for them in the present. Most non-science students avoided math wherever they could, and they and the science students struggled painfully with it when avoidance was not possible. The problem that math represents for them can be clearly understood when one views the statistics of Indian career choices--fewer than five PhD's in mathematics in the country; fewer than ten PhD's in the physical sciences, the most math-related of the natural sciences; less than fifteen PhD's in the "hard" or quantification-oriented social sciences and fewer than five in economics, less than two hundred engineers and fewer than twenty in the computer fields. (Most are in low-level two-year programs.) In the small sample of eighty-five students interviewed for the "Barriers" project, I spoke with only two math majors, several students who had been tutors, and several science students who had math minors. But I met a large number of science students who had dropped math as a major, and most of those had then entered the biological rather than physical sciences as fields of study.

It was not, however, the lack of math majors that seemed the most significant factor in the study. It was the widespread, operative fear and loathing of math; the widespread fear of failure in math; and the widespread lack of basic math skills needed to do other academic tasks (operate a slide rule, understand calculator operations or computer programs, deal with statistics, measure and calculate chemical substances for lab work) that stood out as major and ominous. Many students simply lacked the basic skills, and they sought out or were assigned tutors to help remedy their skill-related problems. For some of the students, who really perceived their problems as specifically skill related ("I never understood percentages"), tutoring at that problem level worked. They learned to calculate percentage and use a slide rule. For most, however, the skill-related problem was the tip of the iceberg. A large number of students reported dropping courses before they experienced failure or dropping at the first moment they felt a skill inadequacy appearing. ("I was afraid I couldn't hack it"; "I was supposed to take college algebra twice, but I was afraid it'd be too hard"; "I would've had more math but I was afraid of flunking.") A similarly large number reported delaying signing up for a course--usually college algebra or calculus--until they were forced into it by requirements to graduate. Few ever expected to do well in math and nearly all believed

it was the hardest subject they ever had to take. They all seemed to sense that they should have taken more math in high school. (It's essential in college"; "I'm not as good as I could be"; "I have a math and science deficiency now and it's hard to make up"; "I have to catch up in math; it's just not my subject"; "I always tried to get out of math and science courses in school. I went to Indian school and all the other Indians tried to get out of it. But now I wish I'd taken more." "All the counselor kept telling me was to take more math, and now I wish I had.") So, they know that schools think it's important; they know they'll need it, especially those in scientific or technical fields, but fear keeps them out and causes them to avoid the experience of failure. The curious thing is that very few of them had ever actually failed. Even those (surprisingly, more women than men in the sample) who had taken four years of science and math in high school, avoided and feared it.

Why do they avoid it? What has been their experience of math? I asked students what their experience of the history of the development of mathematics had been and they replied that they'd learned about Egyptians' and Europeans' contributions. None had heard of Mayan mathematical systems or the numbering systems of the Sioux, Iroquois, or Algonquian peoples. They had either no knowledge or a negative impression of the mathematical and scientific capabilities of Native peoples.

I asked them what their math teachers had been like in grade school and in high school. Very few replied that math teachers had been bad teachers per se. Several mentioned that teachers were not really math teachers, but coaches, for example, and that was perceived as bad. The predominant feeling was that math and science teachers had the reputations of being hard, tough, unyielding, and difficult. (The teachers and the course had a bad reputation"; "Science and math teachers had a reputation of being hard.")

Several said that their math teachers had been good. ("There's a good math teacher here"; "The math teachers there really lived and breathed math"), but that they just didn't like the subject. ("I like my math teacher here, particularly math methods, but not math.") Specifically and fairly uniformly, the students didn't like the more abstract courses. Algebra and calculus are the most feared, most avoided, most disliked courses of all, while geometry and trigonometry appear to have a more affirmative reputation. ("I tried harder in algebra, but I just slid through. I just don't like it. But I like trig and geometry." "I like courses related to daily life, and I can't see algebra as related to anything"; "I have a general problem in abstract reasoning.") Whether the problem is related to abilities to do abstract reasoning with a Western linear mathematical system, as some scholars have suggested, to poor preparation in abstract reasoning, or to an irrational fear of abstract reasoning, I cannot say. But the students in general, do not like and are afraid of those forms of mathematics which do not have a highly visible application to daily/technically related problems and which require abstraction as a major tool.

Another problem--beyond hard teachers and fear of abstraction--seems to lie in the compulsory and rigidified nature of mathematics learning and school course requirements as the students perceive them. Sometimes, because a particular course was to be taken at a certain period and sequence in the schooling (calculus after college algebra in second semester, freshman year), students were placed in courses they did not feel ready for. ("The counselor insisted I go into calculus, but I knew I couldn't do it and dropped the course before I flunked." Little account of the student's

real capabilities, as determined through testing and personal interview, assessed where the student was. And in another sort of instance, students were told--in so many words--that they ought to be afraid of mathematics; that they would indeed fail. (I got counseled out of mathematics into shop because the counselor said I would flunk"; "I was advised against taking algebra courses because I'd gone to a small school.") In yet a third situation, the student was stopped from going on to a higher level science course because of an arbitrary or rigid course sequence or decision by an administrator, and thus turned off permanently to the subject he/she wanted to take. A very superior Senior Pharmacy student told of wanting to take a senior chemistry course and being told by the principal, a math teacher, that she could not take the chemistry without taking calculus at the same time. She still harbors resentment against the principal, and not at all surprisingly, against math. In my own case, I was told that mathematics deficiencies meant that I should drop out of pre-med. As with the other students, no remedy but dropping or avoidance was suggested.

So, many students drop math courses they need for future work, courses they need for basic skills, courses that would lead them to a greater level of achievement, and courses that could prepare them for certain careers before they fail. They think twice and sometimes quite finally about certain careers in scientific and technical fields because of a perception of themselves as hopelessly incompetent in the mathematical skills needed for the career. Sometimes, as in my case and the case of the Occupational Therapy major who stayed out of the field for several years because she'd been told she'd need a lot of math, their sense of the mathematics competence they need is erroneous. Some students' fear and loathing of math are carried into their elementary education majors and on into the schools where they transmit that feeling to students. And if they teach Indian students, another generation continues the pattern. One suspects that the pervasive fear and dislike of mathematics is not uncommon among schoolteachers in general. How much more problematic is it that such an attitude is passed on to students who have neither role models nor models for success in those areas of learning?

Add to their bad experiences with math learning a generalized negative image of science, scientists, math and mathematicians, and the reasons for their math avoidance behavior becomes clearer. To these students, mathematicians are "calculating, obsessive, sloppy, out of touch interpersonally, isolated, remote, rough teachers, and hard workers." Even those students who had had math teachers they both liked and thought were good teachers felt this way in the abstract about mathematicians. Who would want to be described by most of those terms, and who would want to succeed in a field if indeed it meant that one would become--in the abstract--like those who are the professionals in the field? Mathematics seems to have a mystique attached to it. It is hard, the students feel; in fact, the hardest subject for everyone. They believe math teachers are mean and hard. Only the very smartest people succeed in mathematics, but they are cold, rational, distant, beings lacking in sociability and personal warmth. Math has little pragmatic use, but even when it has clear practical uses, the way to learn those forms of math are blocked and obscured by unpractical, abstract, useless forms. One cannot do anything of scientific importance without mathematics; indeed, without a command of math, one is somehow a lesser light no matter what their other competencies. Math majors are the "brains" in schools. And

most minority and female students, no matter what their real competencies and potential, have difficulty envisioning themselves as "brains."

For traditional Indian students, raised in a community-oriented world where the maintenance of harmony and equilibrium means never being singled out for reward or status, the traditional image of the loner mathematician and the traditional question-answer-test-competition based classroom creates discomfort and encourages failure. When they have no indian people as math teachers, see little application of mathematics to their careers, the learning of mathematics is seen as a form of punishment rather than as either a career/life tool or an orderly, logical system which can bring pleasure in and of itself.

Math, physics and computer-science courses which are both devoid of warm, personal, friendly relationships at the base of problem-solving and which bear no resemblance to the students' real career needs nor to the needs of Indian people as they perceive them cannot succeed. Moreover, when the ultimate goal of a math and physics major is translated into production of graduate level research scientists or teachers, as the Indian students I interviewed perceived it, the limitations of the fields combine with the negative perception of the learning experience to drive students away from those fields altogether. "He didn't value the field, even though he was as good as any student I'd seen," one professor said of a drop-out science major, and the same appears to be true of both drop-out math majors and math-anxious science and non-science students.

But is the picture all bad vis à vis math? It is not, and some attempts to address the problem have succeeded. While I have not seen the adoption of full-scale math anxiety clinics, as in the Wesleyan and Mills College models for women, several programs have developed and are working. At Bacone College in Muskogee, Oklahoma, an NSF-Minority Institutions Science Improvement Program-funded program for the development of individualized mathematics and science curricula has resulted in a considerable change in attitude on the part of students and teachers. The head of the program told me that he had completely altered his opinions about the necessity of a conventional mathematics instruction. And the students, using the programs with tutors, many of whom are Indian, are changing their minds about math and their own capabilities. "I can't take tests," one student said, "but here at Bacone, they have individualized programs and I can work through the problems myself. Also, the math teachers here don't have lower standards because we're Indian." ("I have trouble with Algebra, but now I see it as a challenge. I've read about famous people who've failed many times before they succeeded. My tutor believes in me and I'm learning to believe I can do it. My math deficiency has held me back, but there are good math tutors here, and the individualized programs make it easy to work without being embarrassed.") The one enthusiastic math major I met was a tutor in this program, and he had already worked his own way through calculus and was ready for differential equations when he transferred to the University of Oklahoma in the fall. At other schools like the University of Oklahoma, the BIA Indian Students Services Office and the Indian Engineering Program had provided tutors for the students. And some students had responded again

to the individualized, self-reinforcing tutorial even though no special program had been developed for math instruction. "I dropped school altogether because of math and physics," one engineering student told me, "but I came back and made it with a tutor." For some, the difference was made by finding a teacher they liked and trusted. ("I changed math teachers to one I liked, and then it was okay. My math methods teacher has given me some confidence that I could do algebra. She doesn't embarrass you if you don't know how to do something.") And for others, at the Southwestern Oklahoma State University Minority Biomedical Science Program, for example, the supportive framework of several students in the same program working together and sharing similar anxieties and successes, made the difference between success and failure. "You know, when you work alone, you think it's just you with the problem, but here, I realized I wasn't the only dummy. I could even help someone else sometimes."

Thus, courses, programs, remedical activities--all could be turned around and changed to offer the Indian student a supportive atmosphere for mathematics learning, whatever the ultimate goal of the learning. Individualized, non-competitive, program or relationship-based instruction, tutorials, math anxiety clinics and individual therapeutive sessions for more deeply seated and debilitating problems, exposure to Indian role models in math and math-related fields as well as to Indian peer tutors, programs and courses with an applied focus directly related to a career or community need, initial mathematics skills education based on the math of everyday life, culturally-based mathematics education, demonstrations of processes rather than the formulaic applications of rules to obtain product-answers--all could make the difference in the mathematics experience and competency of Indian students. I cannot help but think that the benefit would be to the scientific, technical and mathematical fields as well as to the general education of Native peoples.

The curious thing is that most of the students in my sample came from public school, and indeed, over 60% of American Indians now attend public schools in urban centers and semi-rural areas, just like the students in the "Barriers" study sample. I have concluded that, in general, the public schools' preparation of most students in science and math is sadly wanting; that it is most doubly wanting when it comes to answering the needs of minority students; that little attempt is made to answer to specific minority characteristics or needs when attempts are made to remedy the problem; and that the kinds of Indian students who do not share in the fairly respectable public education afforded many of the students in my sample may be in worse shape than anyone else. Thus, much of what is wrong with the pre- and post-secondary mathematics education received by these students is wrong with public education in general. Much of what can be said of these students can be said of semi-rural, small town, public school educated, lower middle to lower class students everywhere, and recent test scores tell us that the same can be said of their middle to upper middle class peer groups in the cities as well. But much of what is right about these students--their abilities, perseverance, toughness, essential mental health, aspirations for themselves and their communities is right about any group of students who've struggled to do what they've chosen to do. And there is much that is right about the kinds of educators who have attempted to remove some of the obstacles

in their path to do what they've chosen to do. Mathematics competency is at the heart of a major obstacle both to career choice and to achievement of skills now lacked in Indian communities. And change is needed to insure general mathematics competency for American Indians, both capable and needful of the benefits that a positive change would bring.

SURVEY QUESTIONNAIRES FOR AMERICAN INDIAN MATHEMATICS EDUCATION

The following questionnaires are designed to develop an information bank on the human and material resources in American Indian mathematics education. We are trying to find out what resources exist and how best to make use of those resources in improving Indian math education. The information you submit to the AAAS Project on Native Americans in Science is confidential insofar as the names of individuals and institutions are concerned. We are simply interested in knowing more about what has been done, what works and what doesn't, and who is involved in Indian math education. We hope that each of you presently involved in teaching in an Indian educational setting and those who have been involved in the past will take the time to share your ideas and stragegies with the Project staff so that we can begin to plan for the future. Most especially, we hope you'll tell us what or who else we need to know about and about your potential involvement in future projects or programs developed to assist in improving Indian math education. Indicate below what your preferences are for involvement, with AAAS or with some organization formed especially for action in Indian math education. Please duplicate this questionnaire and send it to anyone you feel would be interested. Though we will systematically send materials to all Indian educational institutions and to majority institutions where we know of people who've worked in Indian education, we know we'll miss someone without the help of other people. So, please fill in as much of the following information as you feel applies to you or as you wish to note. We hope you'll remain in contact and that you'll convey to us any critique of the attached effort.

AMERICAN INDIAN MATHEMATICS EDUCATION/HUMAN RESOURCE QUESTIONNAIRE

1. Name _____

2. Ethnic group/tribe (if applicable) _____

3. Teacher ____ Curriculum Developer ____ Administrator ____
   Other (specify) _____

4. Service in educational level (check all that apply, underline level where majority of service has been): elementary_____secondary _____college _____
   post-graduate _____industry/business _____ adult _____

5. Positions held in Indian educational settings (list from last to first)

   _____

   _____

   _____

6. Positions held in non-Indian educational settings:

_____

_____

_____

7. Degrees or Training: B.S._____ B.A._____ Major _____ M.S. _____ M.A.____

Major: _____Ph.D_____Ed.D_____ Field of Specialization:

_____

Special technical training? Specify_____

_____

8. Have you had any specific training in mathematics education? Specify_____

_____

9. Have you had any special training for teaching Indian students? yes___ no___

Specify_____

10. Have you had opportunities for in-service training in math education? yes __ no __

regularly _____ irregularly ____ Specify _____

11. Have you ever participated in any of the following math-related projects:

curriculum development_____ program/department development_____

program evaluation/review _____ curriculum evaluation/review _____

12. Does your present position allow release time for faculty development activities such as in-service: yes __ no __ or for curriculum development activities: yes__no__

13. Are you planning or do you desire to obtain any particular kind of training in math education? yes____ no ____ Specify, if yes _____

_____

14. Are there any special concerns you have for the teaching of mathematics to Indian students?

Would you be interested in participating in a network of math teachers and curriculum developers working in Indian educational settings? yes ___ no ___

Would you be interersted in contributing to or using a materials/information exchange on math education for Indian students if a forum for such an exchange existed? yes ____ no ____

AMERICAN INDIAN PROJECTS/MATERIALS/STRATEGIES RESOURCE QUESTIONNAIRE

The following questionnaire is designed to begin development of an information bank on American Indian mathematics education and on the projects, progrmas, materials, and strategies that have been used in improving Indian math education. We are especially interested in projects, programs and materials developed in, for and by those working in Indian educational settings, but we'd also like to know about those which were not directed toward Indian education or educators per se, but involved or affected such educators and students.

Projects and Programs (Curriculum, faculty development or evaluation projects; special projects for a particular clientele, e.g., nurses or engineers):

1. Name title of project or program _____

   _____

2. Location _____

3. Name of person reporting project _____

4. Name of person(s) developing project/strategy (if known) _____

   _____

5. Educational level: elementary _____ secondary _____ college _____adult _____
   special students _____ Please specify grade or level within category _____

6. Did this project involve any other groups besides American Indians? yes___ no_____

7. How long did this project last from date of implementation? (please give dates)

   _____

8. Who or which institution initiated this project?_____

   _____

9. Who funded or supported (through release time, etc.) this project? _____

   _____

10. How many professional staff were involved in the project? _____

11. How many students (roughly) were impacted by this project? _____

12. How were the student participants for the project chosen: self-selection/volunteer____
    chosen by teacher/administrator ____belonged to group (e.g., 3rd grade class
    chosen _____ other _____

13. What were the stated goals of this program?

14. Briefly describe the methodology used toward accomplishing these goals.

15. Did the project accomplish the desired goals? Explain.

16. Were evaluation reports of this project prepared? yes____ no____ If yes, are copies of the report availabel? yes ___ no ___

17. What was an estimated or actual cost for planning and implementation of this project?_____

18. Name, address and phone number of project director or person who could be contacted for further information about the project.

_____

_____

19. Are any new projects or programs planned for theis next year? Specify._____

_____

Materials developed or used in project (indicate all which apply)

1. commercially available? yes ___ no ___ If yes, indicate titles and publishers

_____

_____

_____

2. Would you/have you used these again after initial use? yes___ no___ If not, why not?

3. If so, what particular features do you like?

4. Materials especially developed for project? yes ___ no ___

5. Were these materials: complete courses of instruction ____ units within courses ___ special units for use outside of a course ___ materials for use with tutors ____ cojputers ____calculaotrs ____ commercially available materials ____

6. Are the materials available (yes ___ no___) or could they be made available for a specified cost? yes___ no ___ If yes, estimate cost _____

7. Would you have used or did you use these materials again after their initial use? yes____ no ____

8. Approximate length of time used? _____

9. Any revisions since initial development? yes____ no ____ Reasons for revision?

10. Would you be willing to place these materials in an exchange for potential use by other instructors? yes___ no___ Person to contact for permission

_____

_____

Strategies/Techniques/Tools

1. Have you even used (or asked your students to use) any of the following instructional tools, techniques or strategies:

   computer-assisted instruction ____ peer tutorial ____ teacher, teacher asst., teacher aide tutorial ____ hand-held calculaotrs ____ commercially packaged tools (such as Cuisenaire rods) ____culturally-based materials____ game playing/gaming ____individualized instruction units ____commercially packaged programs ____ other _____

2. In general, how did you learn about these tools or techniques? in formal methods coursework ___ from salespersons ____ from colleagues ____ from students ____ from math education publications ____ invented them out of own need _____ other _____

3. Can you make any generalizations about the positive or negative utility of any type (age or grade, rural or urban, child or adult, traditional or non-traditional) specific tools, techniques or strategies with any specific

Indian student clientele? (e.g., peer tutorials for urban teenagers, gaming/game playing with traditional, reservation adults, computer-assisted instruction for rural, traditional children.

4. Do you feel that any of the tools and techniques you've employed are especially relevant to the nneds of Indian people or even to the specific tribe(s) you've worked with? yes____no____ Specify

5. Which factor(s) weigh most heavily in your choice of materials or strategies for a particular client or clientele?

   age____ educational level ____ achievement as measured by tests ____ reading literacy levels ____ professional needs ____ daily life needs ___ easy availability of special tools ____ your own training or use of such tools or stragegies ____

6. Have you had opportunities for formal training in the use of particular strategies or tools? yes ____ no ____ specify

7. If you could obtain a particular kind of training, what would you be most interested in?

8. Do you feel that special approaches need to be developed for use in an Indian educational settings? yes____ no ____ or do you feel that most approaches, techniques and strategies common in non-Indian education can be adapted for use there? yes____ no ____

9. If it were available, would you be interested in some form of interchange on techniques and strategies between instructors teaching in Indian educational settings? yes ____ no _____

Conference on American Indian Science and Health Education

The Conference on Health and Science Education in American Indian Post-Secondary Institutions was convened by the AAAS Project on Native Americans in Science, with support from the Division of Research Resources, National Institutes of Health (NIH), 17–19 February in Denver. Following is a report of and commentary on the conference proceedings by Rayna Green, director of the Project, and Janet Welsh Brown, head of the AAAS Office of Opportunities in Science (OOS).

Thirty-nine American Indian post-secondary institutions exist in the United States, varying in age, facilities, support, and function, but sharing a common goal of providing education to meet needs as Indians themselves have defined them. The predominantly Indian colleges have begun to develop educational programs to meet tribal needs—for Indians based both on and off reservations—in fields such as natural resources, energy, health care delivery, and technological/engineering sciences. Recognition of the potential of these institutions for improving the general health and science literacy of Indian people, for broadening health and science-related career options for Indian students, and for supplying Indian human resources in technical fields, led the AAAS Office of Opportunities in Science to initiate work with the institutions. To bring key personnel together to discuss requirements and design strategies, the Office's Project on Native Americans in Science called the Conference on Health and Science Education in American Indian Post-Secondary Institutions.

Conference participant Frank Dukepoo of San Diego State University shares a light moment with AAAS Office of Opportunities in Science head Janet Welsh Brown.

Faculty members and administrators from 21 of the Indian institutions participated in the conference, along with several distinguished American Indian scientists—Frank Dukepoo (Hopi) of California State University at San Diego; Clifton Poodry (Tonawanda Seneca) of the University of California at Santa Cruz; Jack Ridley (Western Shoshone) of the University of Idaho; and Albert Snow (Caughnawaga Mohawk) of the Eastchester, New York, Public Schools—and two science educators, James Rutherford of New York University and Robert Tinker of Springfield, Massachusetts, Technical College.

Also participating were staff members from the conference's co-hosts, the American Indian Higher Education Consortium and the Division of Planning Resources in Minority Education, Western Interstate Commission on Higher Education. Thomas Bowery, director of the Division of Research Resources at NIH, and Ciriaco Gonzales, director of the Division's Minority Biomedical Support Program, also attended. It was their interest in the Indian colleges as potential sites for biomedical research and for the training of Indian biomedical personnel that made this initial conference possible.

An overview of health and science education at Indian post-secondary institutions is complicated by the significant differences among them. (Perhaps their only common characteristic is that, with one exception, they are all 2-year schools.) They are spread from North Carolina to Alaska. Three are federal (Bureau of Indian Affairs) institutions; two are church-related schools; some few are satellite campuses of state college systems; and one is a unique Indian-Hispanic college. However, the largest and fastest growing number are tribally chartered institutions, mostly reservation-based and serving specific tribal populations. Of these schools, several have sought and secured affiliations with state community college systems and work in various ways with other educational agencies in and out of state.

The type and amounts of financial support—state, federal, and private—vary as much as the institutions' purposes and emphases. Thus, health and science programs range from traditional basic science and math courses typical of many junior colleges, to specific programs such as licensed practical nursing and single courses such as range management, field biology, or emergency medical techniques. Most schools have few or inadequate facilities for basic science programming, and few have special funding for such offerings. Most have difficulty obtaining faculty for health, science, and mathematics programs, and Indian teachers are rare in such fields. Yet several institutions have sought and obtained outside funding from the National Science Foundation and NIH. They have planned programs, adapted old facilities, secured faculty, and are busy preparing students in these crucial fields.

One priority need reflected in programming at these institutions and stressed by participants at the conference is for an educational program based on the resources of the Indian community, respectful and inclusive of Indian scientific systems of inquiry. Arctic biology, mathematics for daily reservation life, forestry based on traditional systems, and pharmacy courses which utilize knowledge about Indian medicines were projected as possibilities for these Indian college courses. It is expected that health and science programming will reflect tribal and regional differences as the schools grow and serve Indian peoples.

The AAAS Project on Native Americans in Science will compile information on the health and science programs in American Indian post-secondary institutions, and will work cooperatively with the federal and private agencies and schools to facilitate information interchange to support the kinds of strategies the institutions require. For further information, write to Rayna Green, Director of the Project on Native Americans in Science, AAAS, 1776 Massachusetts Avenue, NW, Washington, D.C. 20036.

Photograph by Martha Ross Redden

Conversing over dinner during the Conference on Health and Science Education in American Indian Post-Secondary Institutions are Thomas Bowery (left), head of the Division of Research Resources, NIH, and James Tutt, director of the Shiprock Branch of Navajo Community College.

Reprinted from Science:196,pp.46-47
(1 April 1977)

017
BEST COPY AVAILABLE